NASA TECH BRIEF

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Separation of Two Bodies in Space

The problem:

To develop an automated analytical tool for solving problems of two-body separation in space.

The solution:

A computer program for the motion of two rigid bodies in space, separating as a result of any one, or a combination of, the following force mechanisms: springs with ball ends, springs with one end guided, pyrotechnics, rockets, cold-gas jets, air pistons, and coulomb drag.

How it's done:

The basic approach to the problem is a straightforward application of the Lagrange equations, augmented by undetermined multipliers. The mathematical complexity of the resultant equations is primarily due to the large number of degrees of freedom (12) and the coordinate transformations involved.

The forces arising from the various mechanisms are represented by mathematical models. The models assume two rigid bodies subjected to the action of forces from the following types of idealized devices: linear springs hard mounted on one body and bearing on the other (either with frictionless slippage or no slippage); linear springs between the two bodies, with universal joints at both ends; pryotechnic devices applying impulsive forces; cold-gas jets – adiabatic processes of an ideal gas; pneumatic pistons – adiabatic processes of an ideal gas; coulomb drag between the bodies; and rockets (constant force), including linear changes in inertia properties.

The primary assumptions concerning the forces are implicitly contained in the descriptions of these idealized devices. It has been assumed that the bodies do not have separation distances that are significant relative to the distance from the common center of mass (CM) to the center of any external force-field. The equations of motion are written in a reference frame that has fixed directions in inertial space but moves with the pre-separation trajectory of the two bodies; this frame is assumed to be inertial. The results are then correct (when used in combination with a trajectory solution for the common CM) if there are no forces acting other than the ones considered in the analysis, or if there is an external force-field exerting approximately the same vector force per unit mass on each element of the system.

No approximations are used in the derivation of the classical equations of motion; they are numerically integrated by the Adams-Moulton method.

Notes:

1. The program is written in FORTRAN II and FAP for use on the IBM 7094 computer. The SC 4020 plotter is also used in plotting a part of the output.
2. Inquiries may be directed to:
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